

1 MONOLITHIC WEIGHT SENSOR

2
3 TECHNICAL FIELD OF THE INVENTION

4 The present invention pertains to a preferably monolithically constructed weight sensor.

5
6 BACKGROUND OF THE INVENTION

7 Weight sensors are known from the prior art and are employed particularly for electronic
8 balances operating according to the principle of electromagnetic compensation. In this type of
9 scale, a load receiver guided movably with respect to a base body is subjected to a weight to be
10 weighed, this weight normally being reduced by means of transmission elements and ultimately
11 compensated by means of an electromagnetic coil.

12 The weight sensor is preferably constructed monolithically, i.e., from a single piece, in
13 order to avoid nonuniform heat strains or other disruptive properties originating from differing
14 materials.

15 A weight sensor in which at least three force-reduction translating levers are provided is
16 known from DE 199 23 207 C1. A section fixed relative to the housing extends into the area of
17 the translating levers so as to form support points for the latter. The projecting section here runs
18 essentially symmetrically relative to an imaginary vertical plane passing through the coil and the
19 weight sensor.

The problem of the invention is therefore to offer a weight sensor that can be manufactured in a simple manner, with a compact design, and therefore economically.

The present invention starts from the recognition that an advantageous and simple construction of monolithic weight sensors can be achieved by forming or arranging individual force-translating elements asymmetrically, at least in part, relative to a plane E. Structured space is saved thereby and machining is advantageously simplified, as will be seen below.

A simplest embodiment of the invention is accordingly constructed such that the weight sensor comprises a fixed base body and a load receiver. The load receiver is separated from the base body in a certain direction X, articulated to it by means of parallel guide elements, and serves as an absorption for a weight to be detected. It is also movable in a direction Y perpendicular to direction X, and thus in the direction of the weight applied to the load receiver.

Also provided are force-translating elements acting in series in the sense of a levered force transfer. These force-translating elements, which reduce translated forces according to the simple laws of leverage, for instance, are coupled together such that the force introduced into a first force-translating element is reduced by a factor, and this reduced force is introduced into the

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1 next force-translating element. A weight can be reduced by such coupled force-translating
2 elements down to the magnitude required for electronic detection.

3 That element which directly or via a coupling element experiences the force introduced
4 into the load receiver is referred to below as the "first" force-translating element. The additional
5 elements are then arranged, starting from the load receiver, in a conceptual force flow direction
6 "downstream" of the first force-translating element towards the coil, wherein coupling elements
7 that relay the force to be transferred essentially unchanged can be provided between the force-
8 translating elements.

9 The last force-translating element will be understood below to be that element which
10 effects the last force-translation process in the direction of force flow. On this last translation
11 element, or on a lever arm disposed thereon, is arranged the aforementioned coil, which is to
12 compensate the weight-induced deflection of the last force-translating element with a suitable
13 current.

14 For an understanding of the above-mentioned asymmetrical arrangement, let an
15 imaginary plane E be provided that extends in the X and Y directions, thus also in the direction
16 of the weight applied to the load receiver, and divides the load receiver or the weight introduced
17 into it symmetrically and vertically. Preferably, a homogeneous introduction of weight into the
18 load receiver is assumed so that the plane divides the introduced weight into two equal parts.
19 With a central arrangement of the coil, it is accordingly also symmetrically divided.

20 The prior art provides for the force-translating elements to be constructed symmetrically
21 to the plane so as to generate allegedly equal loads in the "parallel" components of force-

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1 translating elements divided, for example, in a fork shape. This requires a relatively large design
2 and manufacturing expense and does not optimally handle the loads on the weight sensor. The
3 advantage of an at least partially asymmetrical arrangement of at least one force-translating
4 element is that one can forgo additional undercut machining as is required for symmetrical or
5 divided force-translating elements.

6 In the prior art, a projecting part of the base body extends in the X direction from the
7 base body into the area between the force-translating elements in order to form the specified
8 bearing points there. The extension of the projecting part of the base body in the Y direction is
9 expediently chosen to be as large as possible to maximize the rigidity of this part against a force
10 in the Y direction. This effort is spatially impeded, however, by the force-translating elements
11 running essentially in the X direction. In the prior art this was remedied in that the force-
12 translating elements run symmetrically and in a fork shape on both sides of plane E, while the
13 projecting part of the base body extends as far as possible in the Y direction in the intermediate
14 space of the fork. The price of this, however, is that the divided force-translating elements of the
15 two opposing sides of plane E must be machined mirror-symmetrically in order to guarantee a
16 uniform force transfer in the two parts of the divided force-translating element. Correspondingly
17 longer machining times and higher costs are the result.

18 The device of the invention, on the other hand, proceeds from the idea that the maximum
19 possible rigidity of the projection base body part can be combined with simple and economical
20 machining in the manufacturing process if at least one force-translating element is formed
21 asymmetrically relative to plane E. It is provided, for instance, that the projecting part of the base

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1 body on one side of plane E be formed in the Z direction up to the edge of the normally
2 cuboidally-shaped load receiver, while it simultaneously retains a maximal extension, and thus
3 rigidity, in the Y direction.

4 On the other side of plane E, the above-described maximal Y extension is not retained up
5 to the edge of the load receiver. Instead, it is possible for one or more force-translating elements
6 to be arranged on this side, and thus laterally relative to the projecting part of the base body.
7 These elements can then be produced by access from only one side of plane E, since a
8 corresponding second fork tine of the element is missing on the other side of plane E due to the
9 absence of a symmetrical design. The last force-translating element, or even those preceding it,
10 can then again be run together symmetrically to plane E by means of appropriate cutouts and
11 formed towards the coil, if the coil itself is to be arranged symmetrically relative to plane E.

12 A simple embodiment of the present invention provides, for instance, that the first force-
13 translating element is formed at first, in the area of its coupling to the load receiver or a coupling
14 element, over the entire Z width of the weight sensor. In particular, the bearing point for this first
15 force-translating element is also formed as wide as possible in the Z direction in order to be able
16 to absorb the relatively large forces and possibly torsion moments at the bearing point
17 effectively.

18 In its extension in the X direction towards the coupling point for the subsequent force-
19 translating element, however, the first force-translating element is formed asymmetrically
20 relative to plane E so that the projecting part of the base body can extend in the Y direction into
21 the area not occupied by this first force-translating element. In this way, the rigidity of the

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1 projecting part is optimized, as described above. The additional force-translating elements
2 arranged in series are then arranged in the Z direction essentially to the side of the projecting part
3 of the base body and thus asymmetrically relative to base plane E. The force introduced into the
4 first force-translating element is thus introduced into the subsequent force-translating element
5 either on only one side of plane E or at least asymmetrically thereto.

6 According to this embodiment, the additional translation processes then take place on the
7 one side of plane E, but at least asymmetrically relative to it, with the possibility that the last
8 force-translating element with its arm bearing the coil can again be guided into a position
9 symmetrical to plane E by suitable cutouts.

10 Another advantage of the present invention results from the fact that the individual
11 bearing points for the force-translating elements are arranged on the base body such that it can
12 retain a simple shape with relatively few recesses. The prior art on the other hand requires a
13 complicated structure of the base body since the individual bearing points must often absorb
14 forces in various directions.

15 A particularly advantageous embodiment of the invention therefore provides that all
16 forces impinging on at least one force-translating element be oriented parallel or antiparallel to
17 one another. Such a condition results if at least one force-translating element is constructed as a
18 lever, in particular, one without relevant angles. The forces impinging on the force-translating
19 element therefore point in the same or in the opposite direction, whereby a simple form of this
20 element becomes possible. In comparison to the prior art, it is obvious that the forces in the latter
21 impinge in mutually perpendicular directions on the element and usually have a complicated

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1 form, naturally with many angles, thereby robbing space; manufacturing it is complicated and
2 time-consuming, especially in a monolithic design.

3 Another advantageous embodiment of the invention provides that each of the force-
4 translating elements that is used is oriented such that the impinging forces are all oriented
5 parallel or antiparallel relative to one another. Especially with such a requirement, a particularly
6 compact construction or arrangement of the elements is possible. All translation forces inside the
7 monolithic block are therefore oriented in one direction (e.g. Y) or opposing one another. The
8 arrangement of bearing points, on which the force-translating elements are supported relative to
9 the stationary base body, can be chosen in an uncomplicated and stable manner, and
10 manufacturing also becomes simpler because of the absence of angular constructions.

11 A particularly elegant embodiment of the invention provides that the force-translating
12 elements used for force transfer are arranged in an essentially spiral structure. In this way the
13 force-translating elements can be nested in a sense, because the individual levers are essentially
14 parallel to one another, while the force "runs along" the levers in a spiral shape and is stepped
15 down in the process.

16 In one embodiment of the invention, three force-translating elements are arranged in the
17 sense of a spiral structure. Viewed in an imaginary third direction Z perpendicular to first
18 direction X and second direction Y, the profile of the force-translating elements, possibly in
19 conjunction with the aforementioned coupling elements, appears as a spiral profile. Starting from
20 a first coupling element arranged directly on the load receiver, the first force-translating element
21 runs essentially perpendicular to the first coupling element in the X direction. This first force-

1 translating element is also supported on the base body via a bearing point such that it acts like a
2 lever. A second coupling element, again running essentially perpendicular to the first force-
3 translating element, transfers the initially reduced force to a second force-translating element
4 that again runs perpendicular to the coupling element and therefore parallel to the first force-
5 translating element. In the direction of force flow, the third force-translating element follows via
6 a third coupling element. It is essentially parallel to the two other force-translating elements
7 arranged between them. If one follows the force flow up to the coil, its shape, or the arrangement
8 of the force-translating elements, in the aforementioned spiral structure is obvious.

9 Considerable structural space is saved by nesting the individual force-translating
10 elements, with the necessary dimensioning of the individual elements having to be taken into
11 account at the same time. With a decreasing force to be transferred, the required profile of the
12 individual elements naturally also decreases, so that the elements situated further to the inside
13 can be correspondingly smaller.

14 One advantageous embodiment of the invention provides that a section of the final force-
15 translating element or of the lever arm arranged thereon penetrates through the spiral structure
16 from the inside to the outside in order to introduce or remove an external force. Such an
17 arrangement supports the compact construction of the weight sensor in the aforementioned spiral
18 structure on the one hand, and on the other creates sufficient room to compensate the deflection
19 of the final force-translating element with the possibly rather large coil.

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1 Another advantage of the embodiment is that the final force-translating element
2 constitutes a large step-down stage due to the longer lever arm, which is, after all, the function of
3 the force-translating element.

4 The final force-translating element or a lever arm arranged on it penetrates the spiral
5 structure through, for example, a cutout that is provided in a coupling element or one of the other
6 force-translating elements. The arm bearing the coil can thus be integrally formed as a part of the
7 final force-translating element or formed as a separate arm to be fastened thereon. The latter
8 facilitates manufacture or assembly; the former maintains the monolithic construction of the
9 device.

10 The inventive asymmetrical arrangement of the force-translating elements and the
11 construction of the projecting part of the base body can be further refined if this projecting part
12 of the base body comprises at least one gradation in the X direction and/or the Z direction. With
13 an appropriate gradation of the projecting part, its rigidity can be adapted to the respective force
14 ratios or requirements. Thus a high rigidity of the projecting part is desirable for a relatively
15 large force, as appears, for example, at the bearing point of the first force-translating element. If
16 the force to be exerted on the bearing points is reduced due to step-down translation, then a
17 lower rigidity of the projecting part in the area of the bearing point for the respective force-
18 translating element is sufficient to meet the requirements for precision of the weighing result. In
19 this way, unnecessary accumulation of material can be circumvented, which makes it possible to
20 forgo unnecessary weight.

1 The projecting part advantageously extends into the area which is not claimed spatially
2 by the asymmetrical arrangement of the force-translating elements. For stability it can fill out the
3 space offered to it as well as possible, but it can also be kept smaller in order to save weight or
4 for manufacturing purposes.

5 Another advantageous embodiment of the invention provides that the rigidity of the
6 projecting part in the area of a bearing point be formed qualitatively or proportionally according
7 to the force acting on the bearing point from the associated force-translating element. This means
8 that the contact pressure force on a given bearing point, which decreases in the direction of force
9 flow, influences the associated dimensioning of the projecting base body part. A smaller contact
10 pressure force requires a lower rigidity of the projecting part. This dimensioning can be
11 optimized by matching or sizing the respective support area of the bearing points or of the
12 associated projecting base body part precisely to the loads to be expected.

13 Thus, if a force-translating element brings about a reduction by a certain factor, the
14 bearing point for the subsequent force-translating element can be dimensioned correspondingly
15 thinner and still meet the requirements for weighing precision. A qualitative adaptation therefore
16 implies only a fundamental reduction of the existing dimensions of the projecting part in the
17 respective bearing points, but a proportional adaptation requires a precise calculated
18 determination of the required shape of the projecting part in the area of the associated bearing
19 point as a function of the forces to be absorbed there.

20 Another advantageous embodiment of the invention provides that at least one section of
21 the projecting base body part takes on, in the Y direction, the maximum height between the

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1 parallel guide elements. It is assured in this manner that the projecting base body part has the
2 best possible rigidity to counteract deformation. By virtue of the prescribed asymmetrical
3 construction, the base body part can also ideally extend over the entire height between the two
4 parallel guide elements. Only the recesses of material for delimitation from the parallel guide
5 elements limit the dimensioning of the projecting part in the Y direction. The greater that one
6 can make the projecting part be elongated in the Y direction, the less the force introduced into a
7 bearing point can contribute to deformation of the projecting part and therefore to an erroneous
8 measurement.

9 Monolithic weighing systems constructed according to the prior art, with their force-
10 translating elements constructed symmetrically or in a fork shape, prevent such an elongation of
11 the projecting part or require machining from both sides of the block.

12 Another embodiment of the invention is constructed such that the cutouts arranged
13 between the elements to define them can be made in the weight sensor from only one machining
14 side.

15 Since force-translating elements and the projecting base body part are arranged
16 asymmetrically in the weight sensor, the requirement for parallel structures is largely avoided. In
17 particular, if the projecting base body part extends in the Z direction up to lateral edge of the
18 weight sensor up to its maximum height, then no force-translating element is arranged on this
19 side. This or additional force-translating elements is or are inserted into the opposite side of the
20 weight sensor.

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1 Manufacturing is then advantageously possible from only one side of the weight sensor.

2 All the cutouts that run completely through the weight sensor in the Z direction can be cut in
3 from one side. This saves considerable overall width and permits considerably more economical
4 production than the prior art.

5 With this asymmetrical arrangement, it is also advantageously possible to forgo cutouts
6 in the parallel guide elements. Therefore the latter are formed continuously in the X and Z
7 direction in a favorable embodiment, and offer the maximum stability possible for the guided
8 weight sensor. Since the cutouts that are required for machining in the Y direction according to
9 the prior art become superfluous in the present invention, machining time and thus costs are
10 saved here as well.

11 A particularly advantageous embodiment is characterized in that the weight sensor does
12 not extend more than 30 mm in the Z direction. This particularly narrow construction with
13 simultaneous simple and fast machining can be achieved only because of the asymmetrical
14 construction, in which, for instance, the projecting base body part extends roughly 15 mm in the
15 Z direction from the unmachined side wall up to approximately the middle of the weight sensor,
16 while one or more force-translating elements are formed on the additional 15 mm up to the
17 opposite side of the weight sensor. It goes without saying that a different distribution between
18 projecting base body part and force-translating elements can also be chosen.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will be explained below on the basis of an example in figures.

Figure 1 is a partially cut-away schematic perspective view of one embodiment of the invention.

Figure 2 is a partially cut-away rear perspective view of the embodiment shown in Figure 1.

Figure 3 is a partially cut-away perspective view of the embodiment shown in Figure 1.

Figure 4 is a side view showing the force-translating elements of the embodiment shown in Figure 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

As is recognizable in Figure 1, a weight sensor W is provided that comprises a base body G. Two parallel connecting guide bars P that are capable of guiding load receiver A in a direction Y run along a first axis X. A weight placed on load receiver A acts on load receiver A in the opposite Y direction and tends to push the latter downwards.

Between the two parallel guide bars P, three force-translating elements K_1 , K_2 , K_3 are arranged. Force-translating element K_1 is articulated by a coupling element N_2 to force-translating element K_2 . Force-translating element K_2 is linked to an additional force-translating element K_3 by way of an additional coupling element N_3 .

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1 Load receiver A is articulated to the only partially shown force-translating element K_1 by
2 means of a coupling element N_1 , not visible in Figure 1.

3 All force-translating elements K_1 , K_2 , K_3 are connected to the stationary base body G via
4 bearing points. Force-translating element K_2 is linked at bearing point L_2 , and force-translating
5 element K_3 is articulated at bearing point L_3 . The bearing point for force-translating element K_1
6 is not visible in Figure 1.

7 Force-translating element K_3 extends, partially obscured by upper parallel guide bar P
8 and force-translating element K_1 , with a lever arm H in the direction towards coil S. As can be
9 seen particularly well from Figure 4, lever arm H is subjected to a force that is to be
10 compensated by a suitable coil currents whenever load receiver A is subjected to a load.

11 Load receiver A is symmetrically divided by an imaginary plane E, indicated by dashed
12 lines, which runs along the Y and X directions. In this example, the coil is arranged
13 asymmetrically relative to plane E, but it can also be placed symmetrically thereto.

14 Figure 2 shows the same device in a rear view, so that weight sensor W is shown from its
15 rear side relative to Figure 1.

16 Base body G is again recognizable as well as the two parallel guide bars P, which guide
17 load receiver A in an articulated manner. Additionally visible is the section of force-translating
18 element K_1 extending up to the rear side. Force-translating element K_1 rests via a bearing point
19 L_1 on a part T projecting from base body G. Force-translating element K_1 can be pivoted by a
20 virtual amount in plane E, likewise indicated by dashed lines, or parallel thereto on bearing point
21 L_1 , which is formed into a thin section.

1 Also recognizable is a part of first coupling element N_1 which, obscured by projecting
2 part T, connects first force-translating element K_1 to load receiver A.

3 As can be seen in comparison to Figures 1 and 3, projecting part T is formed only on one
4 side of the imaginary plane E (opposite to the Z direction) up to the edge of the cuboidal shape
5 of the weight sensor, i.e., asymmetrically relative to plane E.

6 In Figure 3, the arrangement of the force-translating elements can be recognized in better
7 detail with parallel guide bars P removed.

8 Coupling element N_1 , which engages with load receiver A, not shown, transfers a force
9 introduced in the opposite Y direction into coupling element N_1 to first force-translating element
10 K_1 . Force-translating element K_1 runs on one side of imaginary plane E in the opposite Z
11 direction up to the rear edge of weight sensor W. On the other side of plane E, force-translating
12 element K_1 does not quite reach the front side of weight sensor W.

13 It extends further in the X direction essentially on only one side of plane E, but in any
14 case asymmetrically thereto, towards base body G. It also rests on a bearing point L_1 , not shown
15 in detail in Figure 3, which is formed roughly analogously to the width of projecting part T in the
16 Z direction on that part T.

17 At its end facing towards base body G, force-translating element K_1 is articulated by way
18 of a coupling element N_2 to force-translating element K_2 . Force-translating element K_2 is
19 connected via bearing point L_2 to base body G, and acts at its end turned towards not-shown load
20 receiver A on third force-translating element K_3 via a third coupling element N_3 . The two force-

1 translating elements K_2 and K_3 are arranged essentially on only one side of imaginary plane E;
2 they thus run laterally (in the Z direction) from projecting part T.

3 Force-translating element K_3 rests on a bearing point L_3 , which extends in the Z direction
4 starting from projecting element T.

5 All the bearing points L_1 , L_2 , L_3 thus constitute a connection to the "solid ground" of the
6 weight sensor, i.e., the immobile mass represented by base body G.

7 Force-translating element K_3 comprises a lever arm H which, concealed by force-
8 translating element K_1 shown in Figure 3, runs asymmetrically relative to plane E through base
9 body G in the X direction to coil S and past it. A calibration force can be introduced at the free
10 end of lever arm H.

11 The spiral arrangement of the force-translating elements becomes particularly clear in
12 Figure 4.

13 Also recognizable is first coupling element N_1 which transfers a force introduced
14 essentially in the Y direction to first force-translating element K_1 , arranged essentially
15 horizontally. The latter rests on previously described bearing point L_1 and acts on second force-
16 translating element K_2 via coupling element N_2 .

17 Second force-translating element K_2 again extends in the direction towards first coupling
18 element N_1 , but terminates a short distance from it so as to be able to act via a third coupling
19 element N_3 on third force-translating element K_3 , which is arranged essentially parallel to and
20 between the first two force-translating elements K_1 and K_2 .

1 If one conceptually follows the introduced and transmitted force, then one recognizes,
2 originating from first coupling element N_1 , a force flow running counterclockwise that winds in
3 a spiral-shaped structure into the interior of the arrangement.

4 Only third force-translating element K_3 interrupts this spiral structure in that a lever arm
5 H articulated to it is led out of the spiral in the X direction through a cutout, not shown in detail.
6 Coil S is arranged on this lever arm H in order to oppose a deflection of lever arm H.

7 As Figure 4 likewise clarifies, only those force-translating elements in which all
8 introduced or exiting forces are directed in parallel or antiparallel are used in the arrangement
9 selected as an example.

10 If a tensile force directed downwards acts on coupling element N_1 , then a bearing force in
11 the opposite direction is produced in bearing point L_1 , while a tensile force is created at coupling
12 element N_2 . The latter is compensated in bearing point L_2 and in coupling element N_3 by an
13 opposing pressure force.

14 From this there originates in bearing point L_3 a tensile force acting in the Y direction, and
15 the force ultimately moving the coil also points in the Y direction or in the direction opposite
16 thereto. Depending on the type of force (tensile or compressive force) that is introduced into
17 coupling element N_1 , the directions of the respectively transferred forces change (in the Y
18 direction or in the opposite direction antiparallel thereto). Forces in the X direction or in the Z
19 direction, not shown, do not appear however, and therefore need not be absorbed at bearing
20 points L_1 , L_2 and L_3 .

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1 As used herein, whether in the above description or the following claims, the terms
2 "comprising," "including," "carrying," "having," "containing," "involving," and the like are to be
3 understood to be open-ended, that is, to mean including but not limited to. Any use of ordinal
4 terms such as "first," "second," "third," etc., in the claims to modify a claim element does not by
5 itself connote any priority, precedence, or order of one claim element over another, or the
6 temporal order in which acts of a method are performed. Rather, unless specifically stated
7 otherwise, such ordinal terms are used merely as labels to distinguish one claim element having
8 a certain name from another element having a same name (but for use of the ordinal term).

9 The above described preferred embodiments are intended to illustrate the principles of
10 the invention, but not to limit the scope of the invention. Various other embodiments and
11 modifications to these preferred embodiments may be made by those skilled in the art without
12 departing from the scope of the present invention.
13